



SUBSTITUTE SPECIFICATION

TITLE: FAN PROTECTION

INVENTOR(S): HUBERTUS C. MIERMANS

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FAN PROTECTION

BACKGROUND OF THE INVENTION

Field Of The Invention

[0001] The invention relates to a protection circuit for a plurality of fans, a cooling system comprising such a protection
5 circuit, and a display apparatus comprising such a cooling system.

Description Of The Related Art

[0002] Japanese Patent Application No. JP-A-61-15594 discloses fans which are each connected to an operating voltage via a series
10 arrangement of a current sensor and a breaker. A comparison calculator compares, for each fan, the actual fan current as measured by the corresponding current sensor with a normal operating current. If the difference between the actual fan current and the normal operating current exceeds a prescribed allowable
15 level, the corresponding breaker is opened. This fan protection device has the drawback that a conductive line is required from each current sensor to the comparison calculator to provide the actual fan currents.

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SUMMARY OF THE INVENTION

[0003] It is an object of the invention to provide a protection circuit for a plurality of fans, wherein the number of conductive

lines required to provide the actual operating status of the fans to a detection circuit does not depend on the number of fans.

[0004] To this end, a first aspect of the invention provides a protection circuit for a plurality of fans, the protection circuit
5 comprising a plurality of elements, each element being associated with a corresponding one of the plurality of fans and having a property with a value depending on an operation condition of the corresponding one of said fans, the elements being arranged in parallel between a reference line and a protection line, and a
10 detection circuit coupled to the protection line for detecting whether a total value of the parallel-arranged elements is in a range indicating that at least one of the fans is in an abnormal operation condition.

[0005] A second aspect of the invention provides a cooling
15 system comprising a plurality of fans and a protection circuit as described above.

[0006] A third aspect of the invention provides a display apparatus having a plurality of fans and a protection circuit as described above.

20 [0007] In the protection circuit for a plurality of fans in accordance with the first aspect of the invention, a circuit (further referred to as the element or elements) indicating the operation condition of a corresponding fan, is associated with each fan. Each element has a property with a value which indicates
25 whether the corresponding fan is operating normally or abnormally.

[0008] The elements are arranged in parallel between two conductive lines. The detection circuit determines the total value of the properties of parallel-arranged elements. If the total value is not within a predetermined range, which indicates that all the fans are operating normally, at least one of the fans functions abnormally. The number of lines required to convey the operation status of the fans to the detection circuit is only two and does not depend on the number of fans involved.

[0009] The protection circuit in accordance with the invention has the further advantage that the total value may indicate how many fans are not functioning properly. For example, if six fans are used, it may be decided to take action only if two or more fans are operating abnormally. In the prior art, all fans will be switched off when a single fan operates abnormally. The protection circuit may protect overheating of an apparatus if one or more fans are operating abnormally.

[0010] Japanese Patent Application No. JP-A-2-230411 discloses a system for detecting fan abnormality, wherein a fuse opens when the corresponding fan operates abnormally. All the fuses are arranged in series. One end of the series arrangement is connected to an input of a detector. A pull-up resistor is connected to the input of the detector. If one of the fans operates abnormally, the corresponding fuse opens the series chain of fuses and the input will be pulled to a high voltage by the pull-up resistor. This prior art does not disclose a parallel arrangement of the elements,

and the detection circuit does not check the value of the properties of the parallel-arranged elements. Moreover, this prior art is unable to detect how many fans are functioning abnormally as it cannot be distinguished whether a single fan or more fans is or are operating abnormally.

[0011] In an embodiment of the subject invention, the element comprises a current source which supplies a current depending on the operation condition of the corresponding fan. The total current caused by the parallel-arranged current sources may be measured directly or converted into a voltage via a common impedance connected to the protection line. The measured current or voltage can be used to determine whether one or more fans is or are inoperative. For example, let it be assumed that the current sources do not supply current as long as the fans operate normally, and each current source produces a predetermined amount of current if a corresponding fan operates abnormally. The number of times that the predetermined amount of current appears in the total current indicates the number of fans that are inoperative.

[0012] In another embodiment of the invention, the current-determining element comprises an impedance element whose impedance value depends on the operation condition of the corresponding fan. The detection circuit determines the total impedance of the parallel-arranged impedance elements. If the total impedance is not within a predetermined range, which indicates that all the fans are operating normally, at least one of the fans functions abnormally.

[0013] In another embodiment of the invention, the impedance element comprises an impedance in series with a switch to decrease the tolerance of the measured impedance.

[0014] These and other aspects of the invention are apparent
5 from and will be elucidated with reference to the embodiments described hereinafter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] In the drawings:

10 [0016] Fig. 1 shows a circuit diagram of an embodiment of the invention;

[0017] Fig. 2 shows an embodiment of a detection circuit in accordance with the invention; and

[0018] Fig. 3 shows a circuit diagram of an embodiment of a fan
15 unit of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0019] Fig. 1 shows a circuit diagram of an embodiment of the invention. Each fan unit F_1 to F_n shown comprises a fan motor M_i
20 and an electronic circuit FM_i for producing a signal IS_i indicating whether the fan motor M_i operates normally or abnormally. This signal IS_i controls an impedance value of an impedance Z_i , or, as shown in Fig. 3, the signal IS_i controls a current of a current source I_i . A power supply 1 supplies a power supply voltage V_s via
25 a common line to the N fan units F_1 to F_n . The power supply current

is returned via a common ground line GND. Each fan unit F_i comprises an impedance element Z_i which has an impedance value dependent on the operation condition of the corresponding fan F_i . The impedance elements Z_i (Z_1 to Z_n) are arranged between a common protection line PROT and the common ground line GND. A detector 2 is connected to the common protection line PROT and the common ground line GND to detect the total impedance of the parallel-arranged impedance elements Z_1 to Z_n . The detector 2 supplies a protection signal FPR which depends on the total impedance of the parallel-arranged impedance elements Z_1 to Z_n . This total impedance is indicative of the operation condition of the fans F_i .

[0020] For example, the impedance of an impedance element Z_i associated with the fan F_i is within a first range when the fan F_i is operating normally, and the impedance is in a second range, which is disjunct with the first range, when the fan F_i is operating abnormally. In a preferred embodiment, as shown in Fig. 1, the impedance element Z_i comprises a series arrangement of an impedance R_i (preferably a resistor) and a main current path of an electronic switch S_i (preferably a FET). A control input of the electronic switch S_i receives the signal IS_i indicating the operation condition of the fan F_i as an input signal. In the example shown in Fig. 1, the control input receives a pulse signal IS_i when the fan F_i is rotating. If the fan F_i stops rotating, the electronic switch S_i becomes conductive or non-conductive continuously. The average impedance value of the impedance element

Zi depends on the duty cycle of the pulse applied to the control input. Thus, the impedance value is lower when the fan Fi is inoperative and higher when the fan Fi is operative, or vice versa.

[0021] A lot of alternative embodiments are possible. The
5 impedance element Zi may comprise a series arrangement of two impedances and a switch in parallel with one of the impedances. When the fan Fi operates normally, the impedance of the impedance element Zi is determined by the series arrangement of both impedances and when the fan Fi operates abnormally, the impedance
10 of the impedance element Zi is determined by one of the impedances only, or the other way around.

[0022] The protection signal FPR may be supplied to the power supply 1 to switch off the power supply 1 if one, or more than a predetermined number, of fans Fi operates abnormally. If the fans
15 Fi are used to cool a display apparatus which comprises processing circuitry 3 to process an input video signal VI to be displayed on a display device 4, the power supply voltages VB1 and VB2 supplied to the processing circuitry 3 and the display device 4, respectively, may be controlled to be disconnected (for example,
20 the power supply is switched off, or the power supply voltage is interrupted) if one, or more than the predetermined number, of fans Fi operates abnormally. It is also possible to selectively switch off only circuits of the display apparatus which substantially contribute to the heating of the display apparatus. For example,
25 the audio amplifiers may be switched off, or the amount of light

produced by the display device may be decreased. The action to be taken to lower the dissipation in the interior part of the display apparatus may be dependent on the number of fans that are operating abnormally. This might be controlled by a microprocessor receiving
5 a signal which is representative of the total impedance of the parallel-arranged impedances or the total current of the parallel-arranged current sources and switches off the relevant circuits, or limits the dissipation by limiting the audio output power and/or the light output of the display device. The signal received by the
10 microprocessor might be obtained by an analog-to-digital (A/D) converter.

[0023] Fig. 2 shows an embodiment of a detection circuit or detector 2 in accordance with the invention.

[0024] The detector 2 has an input terminal P_i connected to the
15 common protection line PROT, an output terminal P_o to supply the output signal FPR, a terminal P_2 connected to ground, and a terminal P_1 to receive a power supply voltage V_s .

[0025] A first comparator COM1 has a non-inverting input, an inverting input connected to the input terminal P_i , and an output
20 connected to the output terminal P_o . A second comparator COM2 has a non-inverting input, an inverting input connected to the input terminal P_i , and an output connected to the output terminal P_o . A resistor R_1 is connected between the input terminal P_i and the terminal P_1 . A capacitor C_1 is connected between the input terminal
25 P_i and the terminal P_2 . A resistor R_2 is connected between the

terminal P1 and the non-inverting input of the comparator COM1. A resistor R3 is connected between the non-inverting input of the comparator COM1 and the inverting input of the comparator COM2. A resistor R4 is connected between the inverting input of the comparator COM2 and the terminal P2. A resistor R5 is connected between the terminal P1 and the output terminal Po.

[0026] The operation of the detector 2 will now be described.

The input voltage V_i at the input terminal P_i of the detector 2 is smoothed by the capacitor C1 and may be determined by the total impedance of the parallel-arranged impedance elements Z_i or by the parallel-arranged current sources I_i . If the input voltage V_i is lower than the reference voltage V_{ref2} at the inverting input of the second comparator COM2, the second comparator forces the output signal FPR to a low level. If the input voltage V_i is higher than the reference voltage V_{ref1} at the non-inverting input of the comparator COM1, the output signal FPR is forced to the low level by the output of this comparator COM1. If the input voltage V_i is in a range between the reference voltage V_{ref1} and the reference voltage V_{ref2} , neither of the comparators COM1 and COM2 will force the output signal FPR low, and, consequently, the resistor R5 causes the output signal FPR to be at a high level (the outputs of the comparators COM1 and COM2 are open collectors).

[0027] Thus, when the total impedance value of the parallel-arranged impedance elements Z_i , or the total current of the parallel-arranged current sources I_i is in a range in which the

input voltage V_i is in between the reference voltages V_{ref1} and V_{ref2} , this is indicative that the fans are operating normally, which is indicated by a high level of the output signal FPR. If one or more of the fans operates abnormally, this total impedance will have such a value that the input voltage V_i is not within this range between the reference voltages V_{ref1} and V_{ref2} , and the output signal FPR has a low level. It is possible to select the reference levels in such a way that more than a predetermined number of fans is detected to be operating abnormally.

[0028] It is also possible to determine the total impedance value of the parallel-arranged impedance elements Z_1 to Z_n by measuring a voltage across the total impedance in response to an applied predetermined current.

[0029] Fig. 3 shows a circuit diagram of an embodiment of a fan unit F_i of the invention. The fan unit F_i shown comprises a fan motor M_i and an electronic circuit F_{mi} for retrieving a signal I_{Si} indicating whether the fan motor M_i operates normally or abnormally. This signal I_{Si} controls a current source I_i to supply different predetermined currents dependent on the operation condition of the fan motor M_i . The fan unit F_i shown in Fig. 3 may replace the fan units F_1 to F_n shown in Fig. 1. The detection circuit 2 of Fig. 2 may measure the total current generated by the parallel-arranged current sources of the fan units F_1 to F_n as a voltage across the resistor R_1 . However, the total current may be measured in any other suitable way.

[0030] It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the
5 claims, any reference signs placed between parenthesis shall not be construed as limiting the claim. Use of the verb "to comprise" and its conjugations does not exclude the presence of elements or steps other than those stated in a claim. The invention can be implemented by means of hardware comprising several distinct
10 elements, and by means of a suitably programmed computer. In the device claim enumerating several means, several of these means can be embodied by one and the same item of hardware.